Historic, archived document

Do not assume content reflects current scientific knowledge, policies, or practices.

ALASKA OREGON WASHINGTON
PACIFIC NORTH WEST
FOREST AND RANGE
EXPERIMENT STATION

USDA FOREST SERVICE RESEARCH NOTE

PNW-149 May 1971

FROST DAMAGE TO WHITE SPRUCE CONES IN INTERIOR ALASKA

by

John C. Zasada, *Silviculturist*
Institute of Northern Forestry

PSW FOREST AND RANGE
EXPERIMENT STATION
SEP 1 1971
STATION LIBRARY COPY

ABSTRACT

Cone and seed production is examined for several white spruce (Picea glauca) *stands in Alaska after a late May frost killed or damaged developing conelets. This is the first time frost damage to cone and seed crops has been observed in this subarctic region.*

Keywords: Frost (forest damage), white spruce, cone damage, tree injuries.

During studies of seed production in 1969 in interior Alaska, an exceptionally warm April and May followed by a relatively mild late May frost permitted the observation of some effects of freezing temperatures on cone and seed production. Although this subarctic region is characterized by a relatively cold climate, this was the first observation of frost damage to white spruce cone and seed crops. Frost damage to white spruce conelets in other parts of the species range has been observed (e.g., Cram 1951; Cayford et al. 1959; Waldron;[1] and Revel[2]).

---

[1] R. M. Waldron. Annual cone crops of white spruce in Saskatchewan and Manitoba 1923-1964. Can. Dep. Forest. Prog. Rep. Proj. MS-158, 34 p., 1965. Unpublished.

[2] Personal communication with Mr. John Revel, British Columbia Forest Service, Red Rock Nursery, Prince George, B. C.

METHODS

Cone damage observations and seedfall collections were conducted in five undisturbed stands--Chena River (CR-1), Bonanza Creek (BC-1, BC-2, BC-3), and T-Field (TF)--and in two stands currently being logged--Chena River cutover (CRC) and Rosie Creek (RC). The Chena River stands are river bottom stands and are about 30 miles east of Fairbanks, Alaska (lat. 65° N.). BC-3 is located adjacent to the Tanana River west of Fairbanks. The other stands occur on gently to steeply sloping upland sites west of Fairbanks.

In the undisturbed stands (except TF; see table 1), cones were counted on 15 trees in each area with a variable power spotting scope (15-60 X). These counts were made from one side of the tree only. In the cutover stands, damage estimates were based on cone counts of branches collected from seven felled trees in each area. Only branches which appeared to have no cones broken off as a result of felling were selected. Cones were divided into two categories:

Damaged cones: dead or damaged cones (fig. 1 and 2, A-M)

Apparently undamaged cones: cones not visibly damaged (fig. 2N)

Table 1.--*Estimated number of living and dead and damaged cones per tree in white spruce stands of interior Alaska, 1969*

Area and elevation (feet)		Living cones	Dead and damaged cones per tree	Percent dead and damaged cones
BC-3,	425	110	0	0
TF,	550	([1])	0	0
CR-1,	650	100	164	62
BC-2,	800	21	40	66
BC-1,	1,250	2	50	96
CRC,	650	240	1,906	89
RC,	750	529	707	57

---

[1] No cone counts were made in this stand; however, seven trees were intensively sampled throughout the 1969 growing season, and no apparent damage was observed on these or other trees in this stand.

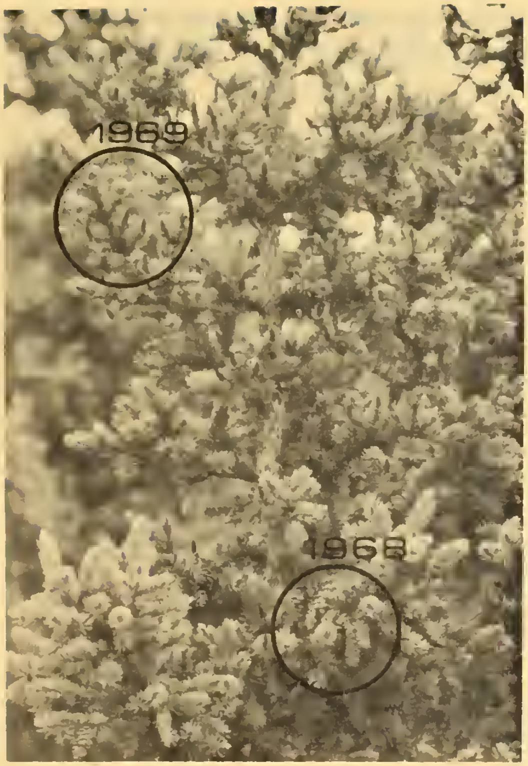

Figure 1.--*Frost-killed conelets, 1969, and undamaged cones, 1968.*

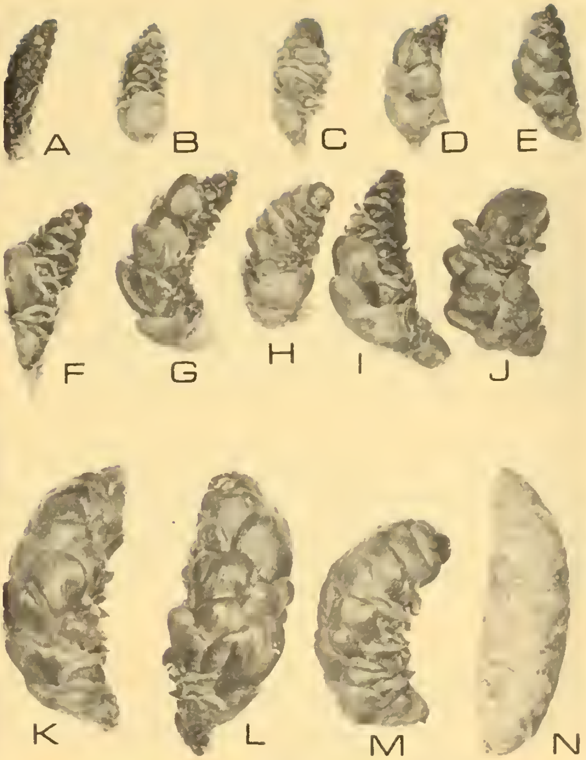

Figure 2.--*Variability in frost damage to white spruce cones. (A--dead cone; N--apparently undamaged cone; other cones have variable number of damaged scales.)*

Cones damaged by frost were collected before seedfall. Seed was extracted from these cones, and germination and cutting tests were conducted on five replicate samples of 100 seeds. Additional information on quality of seed was obtained from seed collected in 10 seed traps in each of the undisturbed stands.

Data on air temperatures were obtained from BC-1, CR-1, TF, and Muskeg[3] field weather stations and from the U.S. Weather Service's (WBFAI, a station located at Fairbanks International Airport) monthly summary of local climatological data for Fairbanks. Thermographs at CR-1 and BC-1 were in instrument shelters 85 feet above ground (this corresponds to the lower to middle portion of the cone-bearing crown). The air temperatures at 85 feet were slightly colder than those recorded on thermographs located at 4.5 feet in these stands. Thermographs at the TF and Muskeg stations were located at 4.5 feet.

---

[3] Data provided by R. J. Barney, Forestry Sciences Laboratory, Pacific Northwest Forest & Range Experiment Station, Forest Service, U.S. Department of Agriculture, College, Alaska.

RESULTS

The minimum air temperatures which occurred varied from 25° to 31° F. between the weather stations as did the duration of temperatures below 32° F. (3 to 10 hours) (table 2). These data indicate that, although variable between stands, the frost did occur throughout the Fairbanks area and was not confined to local areas (e.g., frost pockets).

Damage to the cone crop varied between the study stands (table 1), between trees, between cones on the same tree, and between scales on the same cone (fig. 2). Although the cones shown in figure 2 were collected from a number of different trees, there were individual trees with cones in all of these conditions.

Table 2.--*Maximum and minimum temperatures and duration of freezing temperatures for selected weather stations in the vicinity of Fairbanks, Alaska, May 1969*

Area and elevation (feet)		May				
		25	26	27	28	29
		- - - - *Maximum temperatures (° F.)* - - -				
BC-1,	1,250	62	56	45	54	59
CR-1,	650	62	57	44	57	62
TF,	550	65	60	48	58	65
Muskeg,	550	66	60	47	58	65
WBFAI,	433	68	63	50	61	67
		- - - - *Minimum temperatures (° F.)* - - -				
BC-1		48	30	25	33	43
CR-1		42	32	27	36	41
TF		42	35	30	30	34
Muskeg		30	29	28	34	29
WBFAI		48	34	31	36	39
		Duration of freezing temperatures (hours)				
BC-1		0	2	8	0	0
CR-1		0	1	8	0	0
TF		0	0	6	2	0
Muskeg		1	1	5	0	3
WBFAI		0	0	3	0	0

Germination and cutting tests of seed extracted from damaged cones (mostly in the condition represented by fig. 2, K-M) indicated that germination of all seeds (apparent germination) was 13 percent. Sound seed comprised 17 percent of all seed, and of the sound seed, 92 percent germinated (real germination). The amount of sound seed from seeds collected in seed traps varied from 5.9 to 20.2 percent. These values were 20 to 48 percent of comparable 1968 data (table 3).

Table 3.--*Percent of sound seed from seed collected in seed traps in white spruce stands of interior Alaska, 1968 and 1969*

Area	Percent of sound seed[1] [2]	
	1968	1969
TF	38.7 (535)	18.5 (657)
BC-1	42.1 (478)	14.2 (23)
BC-2[3]	45.7 (741)	19.6 (129)
CR-1	30.2 (468)	5.9 (193)
BC-3	--	20.2 (503)

[1] Based on cutting tests performed on all seeds collected from 10 seed traps located in each stand.

[2] Numbers in parentheses are number of seeds examined.

[3] Additional values for this stand are 1957, 62 percent; 1958, 65 percent; 1959, 22 percent.

DISCUSSION

Damage and mortality of cones can be caused by factors other than frost. That this damage was the result of the frost which occurred on May 26 and 27 is based on the following observations. In BC-1 and CR-1, 5 to 7 days after the frost, the affected conelets were observed to be flaccid, turning black, and open-scaled after pollination. The frost occurred during the period of maximum pollen dispersal; thus female flowers in these two stands were probably at a stage of development believed to be most susceptible to mortality caused by frost in other species (e.g., Campbell 1955; Hutchinson and Bramlett 1964; Barras and Norris 1964). In TF, where no visible damage was observed, 60 percent of cones collected on May 26 (16 cones from each of three trees) had closed cone scales and the remaining 40 percent were partially closed and beyond the stage of maximum pollen receptivity. Simak (1969 and in personal communication) reported frost damage of a similar nature to *Larix sibirica* (Ledeb.)[4] conelets.

In addition to mortality of conelets, the first formed leaves of understory vegetation (particularly *Alnus crispa* (Ait.) Pursh and *A. incana* (L.) Moench subsp. *tenuifolia* (Nutt.) Breitung)[5] were also killed. Weeden and Roseneau[6] reported that newly developing alpine flowers in an area near Fairbanks were frozen at this time.

As indicated by the various levels (stand, tree, cone, and cone scale differences) of damage, the effect of this frost was complex. Several factors which may have been important singly or in combination are stand elevation (table 2), duration of freezing temperatures and minimum temperature (table 2), position of cones in the crown, and stage of cone development.

The most important effect of this frost was the great reduction in cones and seeds in some stands. Two other points should also be mentioned. First, even those stands which suffered no apparent damage to cones had a low percentage of filled seed (table 3). Although this reduction could have been caused by insects or disease, cutting of seed and qualitative observations of cones in these stands indicated this was not the case. In view of reports by Andersson (1965), Sarvas (1968), and Simak (1969), it seems possible that the frost could have prevented formation of viable seed in the apparently undamaged cones. Second, cones damaged by frost did produce viable seed, although in much smaller numbers than produced by undamaged cones. Damaged cones did open and disperse seed.

This was the first observation of frost damage to white spruce cone and seed crops in this subarctic region since observations of cones and seed began in 1957 (Zasada and Viereck 1970). On the basis of the infrequency of this phenomenon, frost may not assume great importance. However, when superimposed on the periodicity of seed crops such frosts may have greater importance. For example, observations of cone and seed production indicate that the cone crop in stand CR-1 may have been the best since 1958. If collection of cones had been required in this area or if other silvicultural activities depending on large amounts of seed had been planned, this frost could have had serious consequences.

---

[4] B. A. Tikhomirov (1966).

[5] Hultén (1968).

[6] R. B. Weeden and D. Roseneau. Game bird report. Vol. XI, Annu. Proj. Segment Rep., Fed. Aid Wildlife Restoration, Proj. W-17-1 and W-17-2, 16 p., 1970. Unpublished.

LITERATURE CITED

Andersson, E.
1965. Cone and seed studies in Norway spruce (*Picea abies* (L.) Karst.) Stud. Forest. Sueica 23, 214 p.

Barras, Stanley J., and Dale M. Norris, Jr.
1964. Effect of a late May freeze on red pine ovulate cone development. Univ. Wis. Forest Res. Note 115, 3 p. (Forest. Abstr. 28. No. 5766.)

Campbell, T. E.
1955. Freeze damages shortleaf pine flowers. J. Forest. 53: 452.

Cayford, J. H., V. Hildahl, L. D. Nairn, and M. P. H. Wheaton.
1959. Injury to trees from winter drying and frost in Manitoba and Saskatchewan in 1958. Forest. Chron. 35(4): 282-290.

Cram, W. H.
1951. Spruce seed viability: dormancy of seed from four species of spruce. Forest. Chron. 27(4): 349-357.

Hultén, E.
1968. Flora of Alaska and neighboring territories; a manual of the vascular plants. 1008 p., illus. Stanford, Calif.: Stanford Univ. Press.

Hutchinson, Jay G., and David L. Bramlett.
1964. Frost damage to shortleaf pine flowers. J. Forest. 62: 343.

Sarvas, R.
1968. Investigations on the flowering and seed crop of *Picea abies*. Commun. Inst. Forest. Fenn. 67(5), 84 p.

Simak, M.
1969. Frostschäden an Lärchen in Schweden. Supplement to Schweizerischen Forstvereins Zeitschriften. Suppl. 46: 115-125.

Tikhomirov, B. A. (ed.)
1966. Vascular plants of the Siberian north and the northern far east. Israel Program Sci. Transl. 5133, 340 p.

Zasada, John C., and Leslie A. Viereck.
1970. White spruce cone and seed production in interior Alaska, 1957-68. USDA Forest Serv. Res. Note PNW-129, 11 p. Pac. Northwest Forest & Range Exp. Sta., Portland, Oreg.

The FOREST SERVICE of the U.S. Department of Agriculture is dedicated to the principle of multiple use management of the Nation's forest resources for sustained yields of wood, water, forage, wildlife, and recreation. Through forestry research, cooperation with the States and private forest owners, and management of the National Forests and National Grasslands, it strives — as directed by Congress — to provide increasingly greater service to a growing Nation.